# TECHNIQUE AND DEVICE FOR THROUGH-THE-WALL AUDIO SURVEILLANCE

## CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority based on U.S. Provisional Application No. 60/557,542 filed Mar. 30, 2004.

## STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] The U.S. Government has certain rights in this invention pursuant to NAS7-1407 provided by the National Aeronautics and Space Administration, Office of Space Science.

## BACKGROUND

[0003] The present invention generally relates to the detection of audible sound and more specifically relates to the detection of sound through an interposed barrier.

[0004] Audio surveillance is an important part of law enforcement activity. The ability to overhear conversations can provide vital information relating to the commission of a crime. One method of detecting sound is to place a microphone proximate the source of the sound. Sound is essentially a pressure wave and the microphone detects sound by detecting fluctuations in pressure associated with the pressure wave.

[0005] Attempts to detect sound using a microphone can be frustrated by interposing a barrier between the source of the sound and the microphone. In instances where the barrier absorbs the energy of the sound pressure waves, then a microphone can experience difficulty in detecting the sound. In addition, a space can be "sound-proofed" to frustrate audio surveillance. Sound-proofing describes constructing barriers that effectively prevent pressure waves associated with sound from escaping a space.

## SUMMARY OF THE INVENTION

[0006] Embodiments of the present invention can detect vibrations of objects including slight vibrations caused by sound pressure waves. In one aspect of the present invention an object is illuminated with a monochromatic RF beam that does not include any amplitude modulation. Observations of amplitude modulations in reflections of the RF beam can provide information concerning vibrations or movements of the object. Audio information can be extracted from the amplitude modulated information and used to reproduce any sound pressure waves incident on the object.

[0007] One embodiment of the invention includes an RF transmitter configured to generate an RF signal having a frequency of at least **100** MHz and an unmodulated amplitude, an RF receiver configured to receive a reflected RF signal comprising an RF carrier having the same frequency as the generated RF signal that is amplitude modulated by an information signal and a signal processor configured to extract audio frequency information from the amplitude of the reflected RF signal.

[0008] In another embodiment of the invention, the RF transmitter includes an RF synthesizer coupled to an antenna.

[0009] In a further embodiment of the invention, the antenna is a planar antenna. In yet another embodiment of the invention, the antenna is a waveguide horn antenna.

[0010] In a still further embodiment, the RF receiver includes an antenna, a low noise amplifier coupled to the antenna, a harmonic mixer connected to an output of the low noise amplifier and to an RF oscillator, a second amplifier connected to an output of the harmonic mixer, a narrow bandpass filter connected to an output of the second amplifier and a diode detector connected to an output of the narrow bandpass filter.

[0011] In yet another embodiment of the invention again, the antenna is a planar antenna. In a still further embodiment of the invention again, the antenna is a waveguide horn antenna.

[0012] In yet another additional embodiment, the low noise amplifier is implemented using MMIC.

[0013] In a still further additional embodiment the signal processor includes an audio speaker. In still yet another embodiment, the RF signal can have a frequency in the range of 100 MHz to 200 GHz. Moreover, the RF signal can have a frequency in the range of 1 GHz to 100 GHz. In addition, the RF signal can have a frequency in the range of 10 GHz to 100 GHz.

[0014] An embodiment of the method of the invention includes illuminating an object with a generated RF signal having a frequency of at least 100 MHz and having an unmodulated amplitude, extracting amplitude modulated information from reflections of the generated RF signal, isolating the portions of the extracted information corresponding to audio frequencies and generating audio using the isolated portions of the extracted information.

[0015] In another embodiment of the method of the invention, the RF signal has a frequency in the range of 100 MHz to 200 GHz. Moreover, the RF signal can have a frequency in the range of 1 GHz to 100 GHz. In addition, the RF signal can have a frequency in the range of 10 GHz to 100 GHz.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0016] **FIG. 1A** is a schematic diagram of a sound detection system in accordance with an embodiment of the present invention illuminating an object with an RF beam through a barrier;

[0017] **FIG. 1B** is a schematic diagram of a sound detection system in accordance with an embodiment of the present invention illuminating the chest of a subject with an RF beam;

[0018] **FIG. 2** is a schematic circuit diagram of a system in accordance with an embodiment of the present invention;

[0019] **FIG. 3** is a schematic diagram of an experimental configuration;

[0020] **FIGS. 4A and 4B** are graphs showing comparisons between audio signal amplitudes and the amplitude modulation of an RF signal detected in accordance with an embodiment of the method of the present invention, where the RF signal is reflected from an aluminum foil upon which the audio signal pressure waves are incident;